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MULTI-SPECTRAL REPRODUCTION FROM ERTS-1

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ERTS-1 in operation for one year

The first earth resources satellite was placed in orbit /127* around earth 23 July 1972 (GN 1973:1). During the first year ERTS-1 has completed approximately 5,000 rotations and from an observation altitude of a little more than 900 km recorded approximately 70,000 original pictures, which have been transmitted to receiver stations in the USA and Canada. From the received picture data 771,000 black and white pictures have been produced and distributed.

Some technical problems concerning the storage of video data in the satellite have arisen and led to reduced capacity. This has especially affected those areas which do not have receiver stations so that direct recording of video data could occur (real time) but have to resort to storing through tape recordings for later transmission during passage over a receiver station. A receiver station in Europe would be desirable and has become of interest because of the problems which arose. A station was constructed in Brazil last year.

Since two Swedish projects were included in the ERTS experiment, it should be possible to cover all of Sweden with ERTS recordings, and the southern parts of the country up to the Väner-Vätter area would be covered by a number of passages. As a result of the data storage problem which occurred as well as unfavorable weather conditions, southern Sweden has not yet been completely covered by ERTS-1 after one year. However, excellent picture sequences are available for certain partial areas.

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* Numbers in the margin indicate pagination in the foreign text.

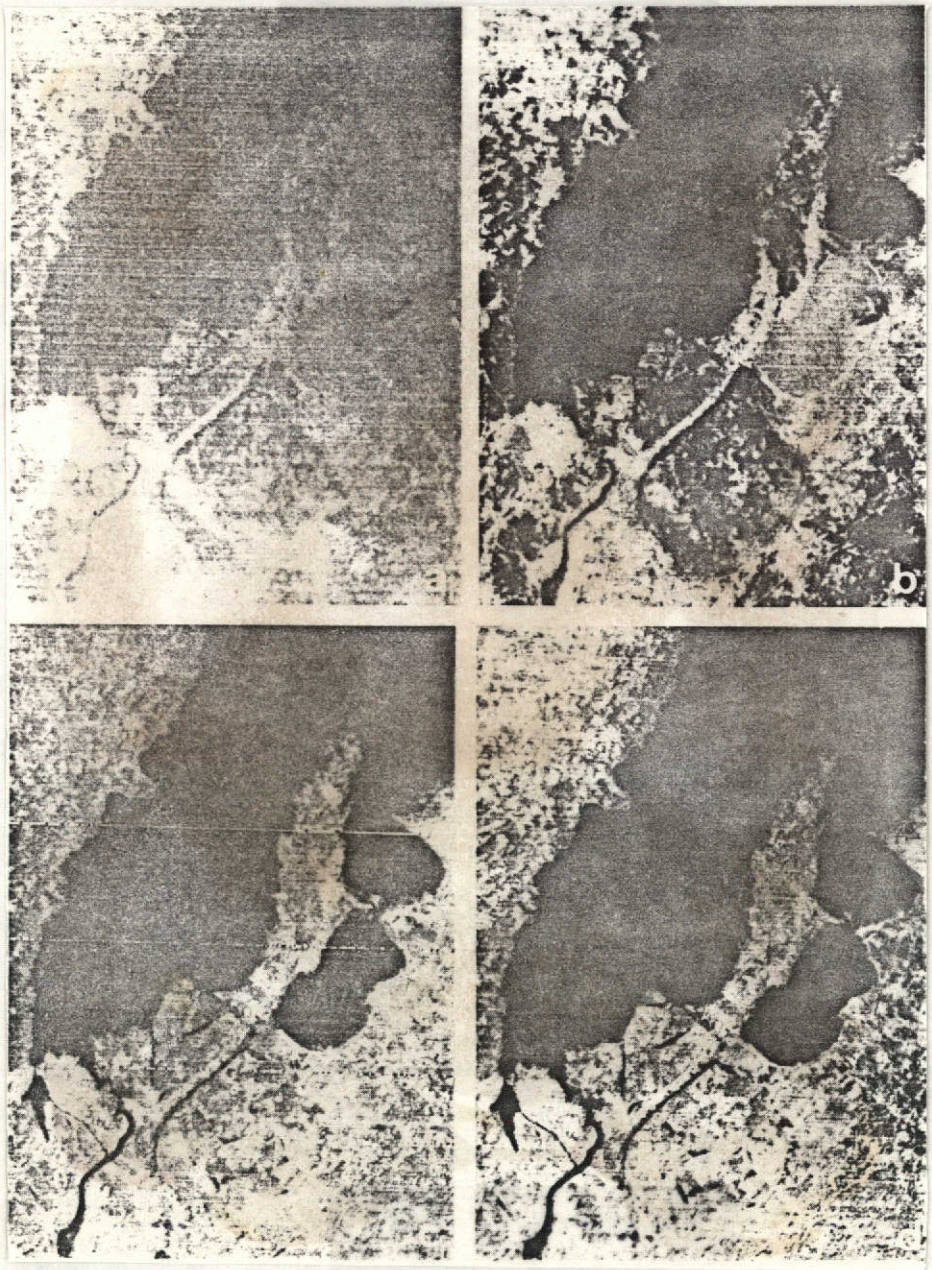

Fig. 1. Multi-spectral reproduction of the southernmost parts of Vänern 19 March 1973 (ref. fig. 2). Approximate picture scale 1:350,000. The picture section a-d corresponds to the spectral ranges 0.5-0.6 μm, 0.6-0.7 μm, 0.7-0.8 μm and 0.8-1.1 μm. Photo material NASA. /128

Fig. 2. The Väner-Vätter area 19 March 1973. Approximate scale 1:1.4 million. The pictures are composed from the channels 0.5-0.6 µm (yellow), 0.6-0.7 µm (red), and 0.8-1.1 µm (blue). Photo material NASA.

ERTS-1 gives pictures in different spectral ranges

The pictures ERTS gives over Sweden comes from a multi-spectral scanner (GN 1970:4). The satellite is also equipped with a television camera system. As a consequence of the reduced /129
data storage capacity, no picture material is made over Sweden. The multi-spectral pictures are recorded in two intervals of the visible spectrum: 0.5-0.6 μm and 0.6-0.7 μm as well as in two intervals of the IR range: 0.7-0.8 μm and 0.8-1.1 μm.

Simultaneous video recording in several spectral ranges makes it possible to obtain more reliable separation of video information. Objects, which have only poor contrast in black and white for recording within a wide spectral range, e.g., all of the visible interval, may give clear reproduction in some of the multi-spectral picture variations because they have their strongest signatures within narrow intervals.

Fig. 1 reproduces the southern parts of Vänern with Halle-Hunneberg and Vänersnäs in accordance with the four channels of the multi-spectral scanner. A comparison clearly shows differences in contrast reproduction for various objects and surfaces. Halle and Hunneberg, for instance, have their clearest borders in b. This is because the forest has its strongest contrast in this channel. The small lakes between the mountains, however, appear best in the IR channels (c and d). The shallow areas in Dättern (east of inner Vänersnäs) can be established by comparison between some of the pictures in the visible range (a or b) and one of the IR variations.

Simultaneous recording in several spectral intervals also makes it possible to combine pictures by simultaneous observation of two or more diapositives. This can also be done by projecting. In this way color pictures can be built up using filter technology. In Sweden there is special apparatus for additive color picture production at FOA (the Armed Forces Research Institute) and at the Nature Geographical Institution in Stockholm.

The color pictures, fig. 2, have been produced according to the diazo method by B. Henriksson, Lund. Black and white diapositives of various channels are contact copied on special film, whereby new single color diapositives are obtained, which can be super-imposed on each other to a composite color picture (e.g., in an overhead projector). The diazo film is available in a large number of colors, which give many possibilities for combination.

The color coding, which can be done with different methods with multi-spectral starting material, serves to emphasize contrast and thus facilitates the analysis of the picture as compared with conventional observation and processing of black and white material.

ERTS-1 gives a regional survey

ERTS-1 picks up in one picture large surfaces and offers great possibilities for regional analysis from widely different points of view. Ground utilization and forest distribution can be analysed in picture material from a suitable season. Figure 2 gives some insight into this, even though it would have been more suitable to take the pictures later (April-May). - Figure 2 identifies (if necessary, by comparison with S. de Geers landform map) many of the fault lines and formation boundaries which have given rise to present day topography in the Väner-Vätter area.

It may not be possible to read out so much new and unknown information for such a well-investigated area as that in figure 2. However, it can be mentioned that from the reporting, which is continuously carried out in the ERTS experiment, several examples were cited where supposedly well-known areas proved to contain unknown structural elements. It can also be stated that /130 the ERTS material permits considerable magnification and thus makes possible a considerably more detailed analysis.

For many areas there is always a need for following the changes which are steadily being made by man's activity. Pertinent picture material is a pre-requisite for this. For under-developed countries with no or incomplete cartographic materials the direct use of ERTS material for inventory of natural resources and planning of their utilization is completely obvious.

The changes which nature goes through periodically are documented in ERTS pictures. It is probable that fenologic studies of regional nature find useful material in picture sequences from ERTS-1. - The seasonal occurrence, which the breakup of the ice constitutes, appears in part in figure 2, where the majority of the lakes are free from ice, but lakes at higher altitudes in the border areas between Småland and Västergötland are still covered by ice and snow. Ice partially broken up lies in bays in northern Vänern as well as in some lakes near northern Vättern (Viken, Boren, Tisaren, etc).

Limitations on the ERTS recordings

When the ERTS material is evaluated, it is often done from optimal picture conditions. What has been said above has also been true for pictures taken under favorable atmospheric conditions. Figure 2 can only serve as an example of such a situation. Continuous surveillance of an area or observation at short intervals is often desirable for military surveillance. This cannot be performed by ERTS-1, whose observation cycle is 18 days. In addition there is the risk of being screened out because of cloud cover.

As far as the observation frequency is concerned, it can be increased by utilizing several satellites and/or by choice of other orbit elements (ref. the weather satellites). However, the cloud cover remains as a problem. In the utilization of sensors for recording of long duration radiation, especially microwaves, this problem could theoretically be eliminated.

Because of weaker radiation intensity in the microwave range, the reception should require greater technical resources and probably still result in picture material with limited resolution properties. Experience from this area will be produced by the current Skylab project, which includes microwave sensors.

It must be emphasized that ERTS-1 is not intended to be an operational satellite. It is an experiment for obtaining experience both of purely technical performance as well as of the possibilities for utilization the picture material may find. This experience from the first resources satellite will form the basis for the design of ERTS- and similar satellite projects in the future.

Abstract

Although ERTS-1 has been in operation for one year, parts of southern Sweden have not yet been photographed because of technical problems and unfavorable weather conditions. Recording in several spectral ranges is shown to be of value for different geographical areas. ERTS pictures can be useful both for analysis of well investigated and relatively poorly investigated areas.